Virtual System Design & Optimization

Annual National Laboratory R&D Meeting
DOE Fuel Cells for Transportation Program

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July 29, 1998

NREL

The National Renewable Energy Laboratory

- A Department of Energy National Laboratory -

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Approach to Working With Suppliers

- NREL has worked with industry on a five-year $300M cost-shared Hybrid Electric Vehicle Program with industry.
- Vehicles are developed using a systems-level approach.
- NREL's capabilities are used to help optimize components.
- Modeling tools are key to providing a systems perspective that most component suppliers are missing.
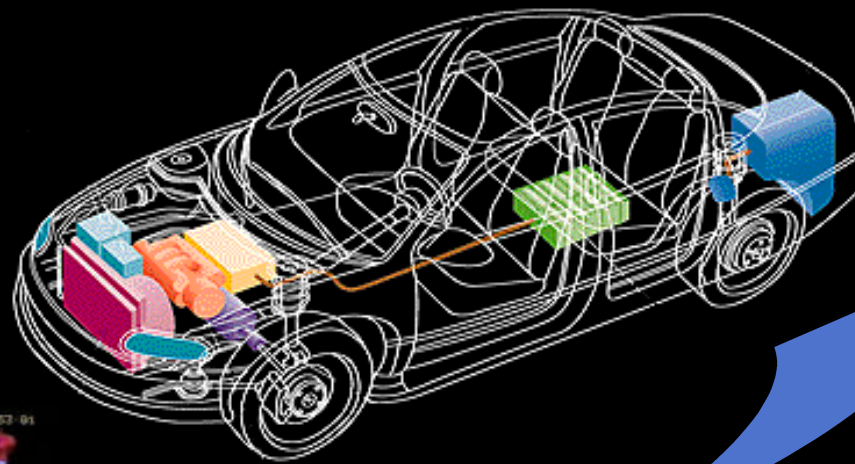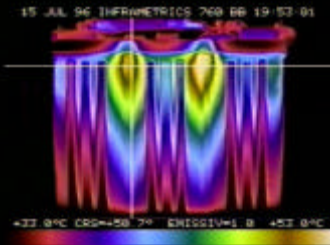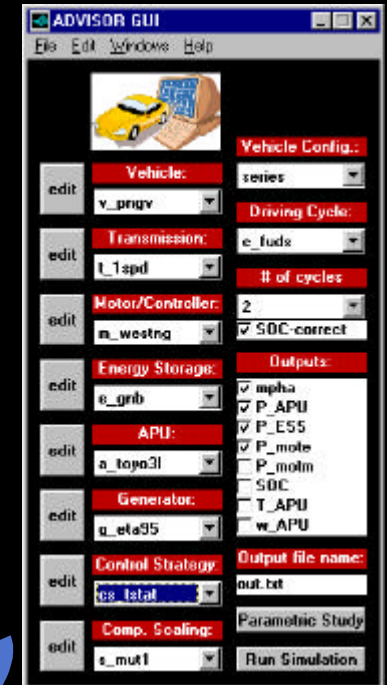
Government/Industry Partnership

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Opportunity for the Fuel Cell Program
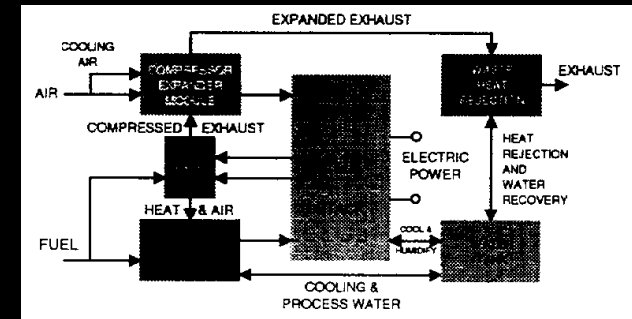
NREL's
ADVISOR
Vehicle Simulation
Model
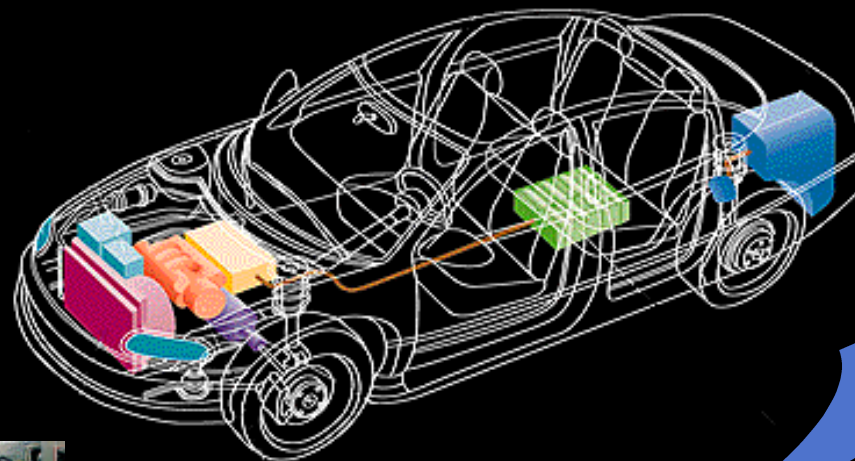
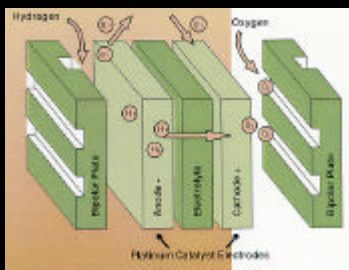Component Design,
Development, &
Optimization

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Opportunity for the Fuel Cell Program

Argonne's

GCTool

Fuel Cell Model

Fuel Cell Design,
Development, &
Optimization

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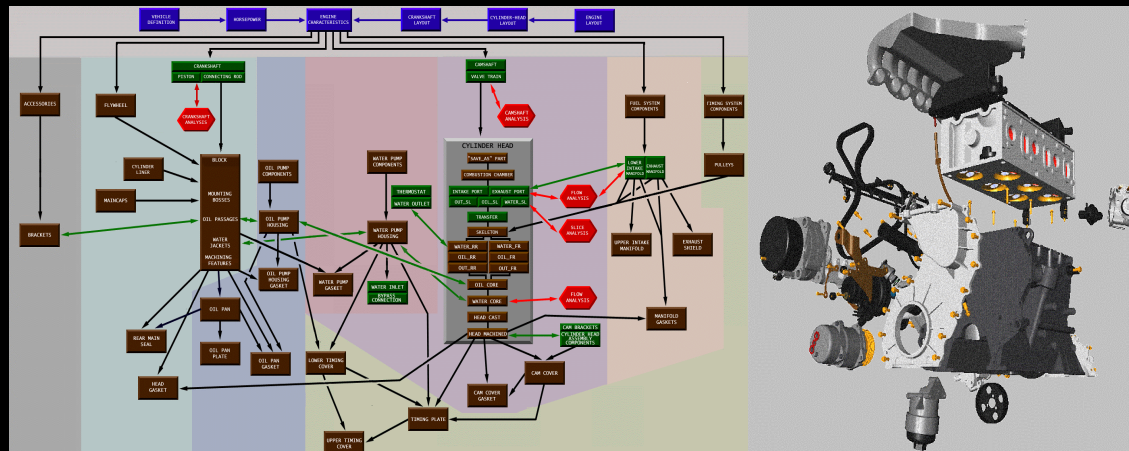
Pro/FUEL-CELL

Next Generation Technology

- Knowledge engine
- Process capturing expert system
- Automated product design and analysis
- Enables evaluation by customized codes
- Provides methodologies, wizards, and process roadmaps
- Utilizes cutting edge technology
  - Parametric
  - Fully associative
- Integration of key third party technologies
- Allows concurrent product development amongst the scientific and engineering community
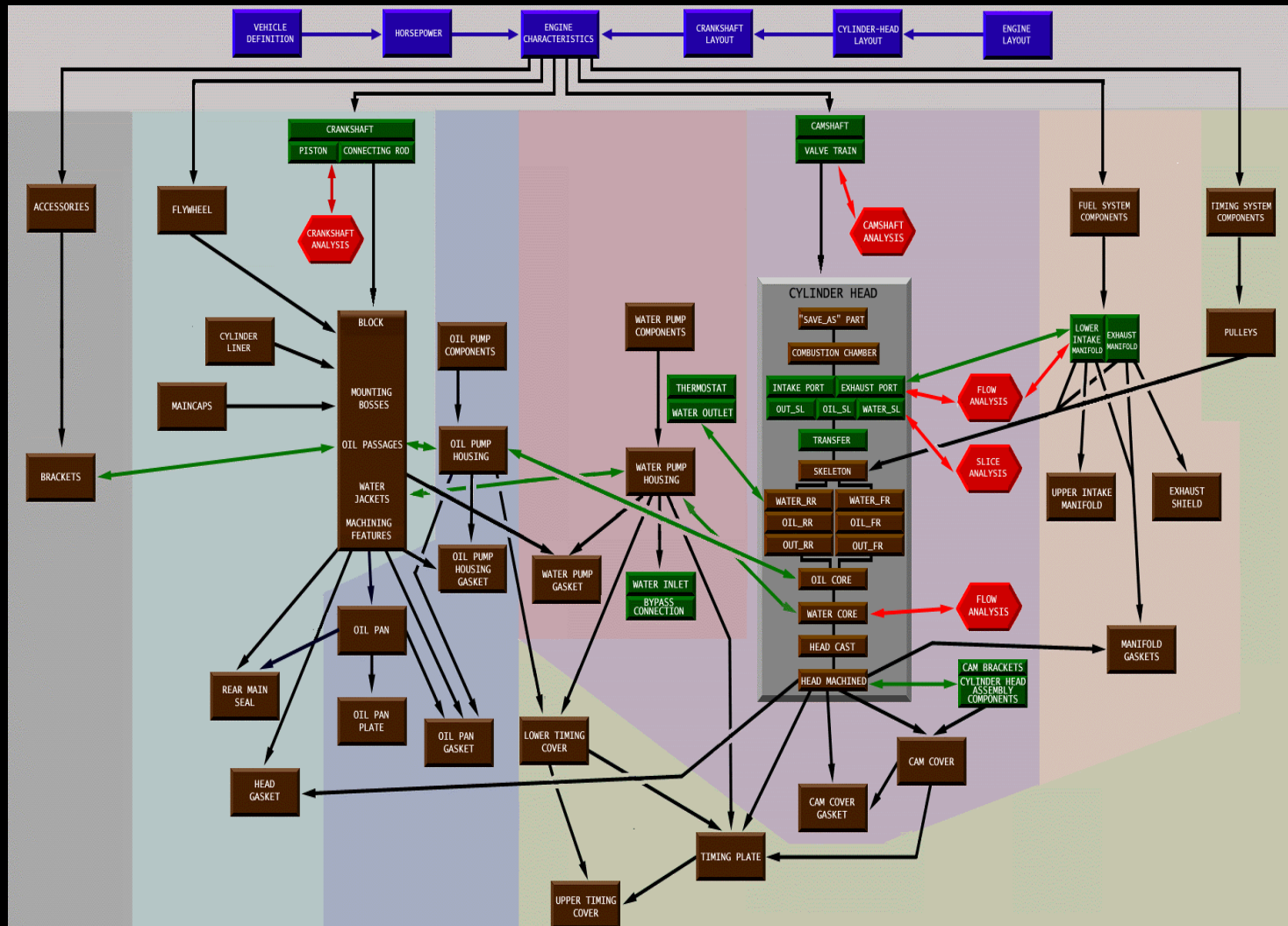
Program Capabilities

Pro/FUEL CELL Development

ä   Enables the evaluation of multiple ideas/iterations

ä   Promotion of process and data reuse

– Leverage existing data and best practices

ä   Efficient utilization of advanced technology

– Reduce the learning curve for advanced product technology

ä   Faster throughput, reduced costs and higher quality

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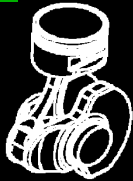
Roadmap/Decision Tree

Fuel Cell Design Process

Specifications & Requirements
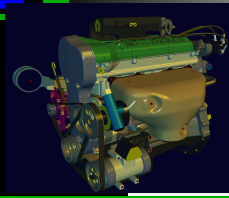
- Cost
- Performance
- Emissions

Concept Design

- Stack
- Fuel processor
- Balance of system
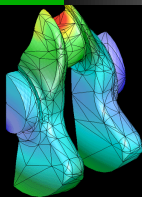
Desktop Analysis

- Cell performance
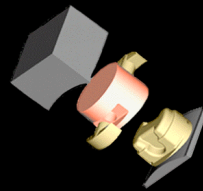- Cell/stack geometry
- H_2O/thermal management

Optimization and Validation

- Start-up/transients
- System optimization
- Temperature
- Pressure

Manufacturing

- Materials
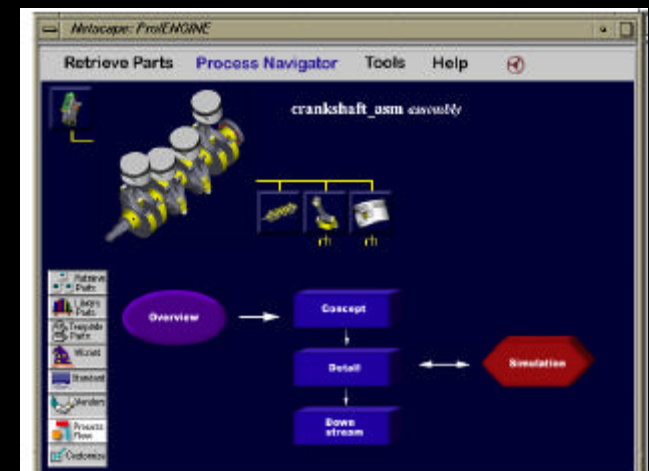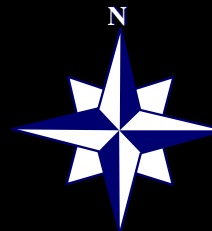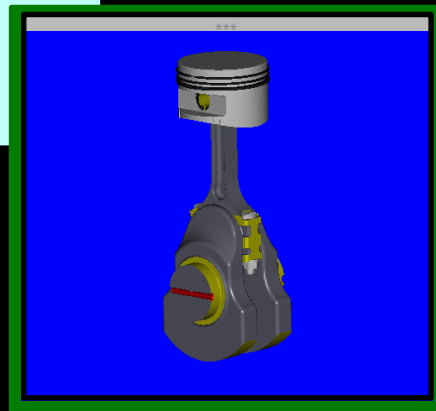- Rapid prototyping
- Manufacturability
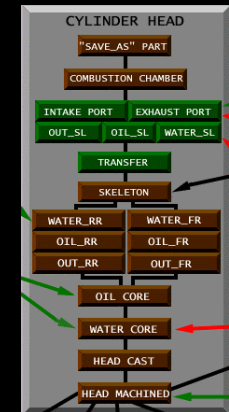
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Process Navigator

Customizable Design Roadmap

- **Web-enabled interface**

- **Process capture**

- **Design tutorial**

- **Complete documentation and integration**
  - *Concept*
  - *Detail*
  - *Analysis*
  - *Manufacturing*

Modeling Wizards

Applications for Part Development Automation

- **Automated part development**
- **Specification-driven**
- **Rule-based design**
- **Reusable processes**
- **Promotes rapid part development**
- **Easy-to-use interface**
- **Access to all data**
- **Based on standard technology**
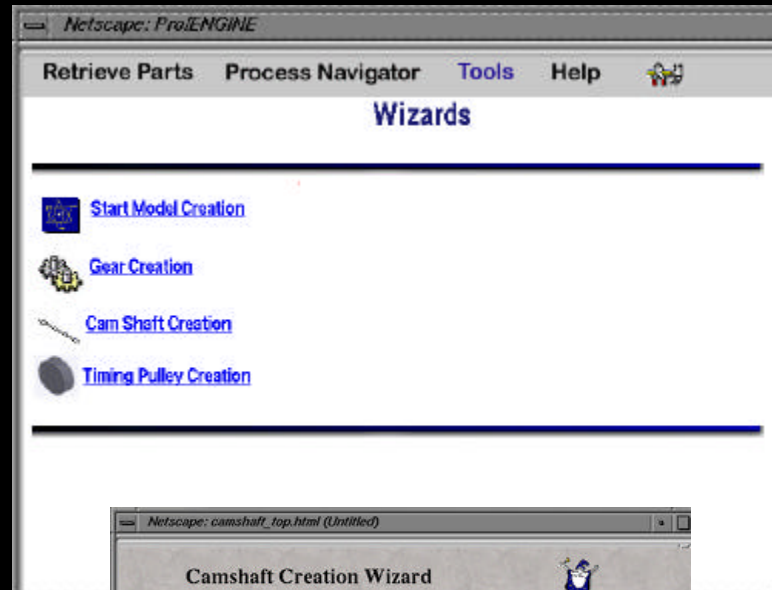
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Optimization & Analysis

Early Insight and Improvement through analysis

- *Facilitates functional simulation of designs*

- *Incorporates analysis into design process early and often*

- *Example constraints and results provided*

- *Aids in scale-up and manufacturability*
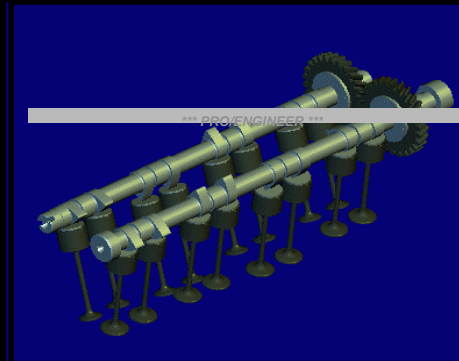
2-D Electrode Structure

CFD Flow Fields

Thermal/ H$_2$0 Mgmt.
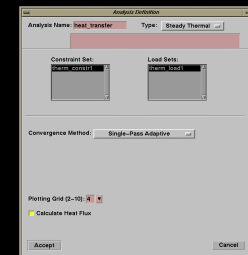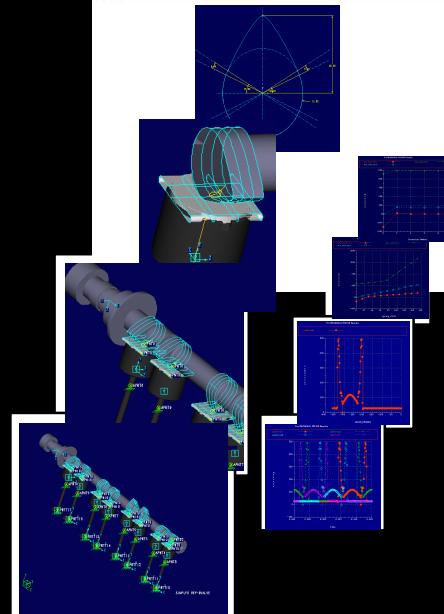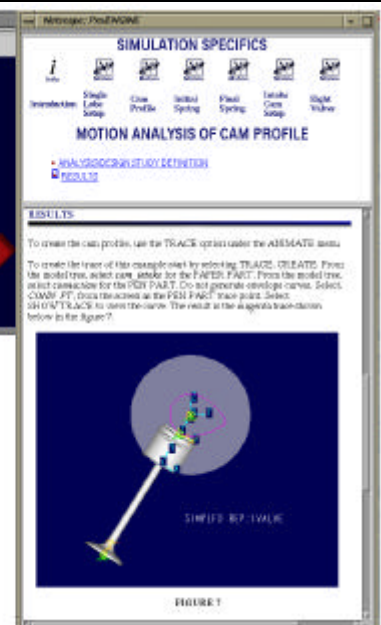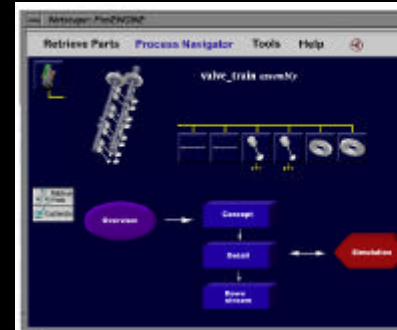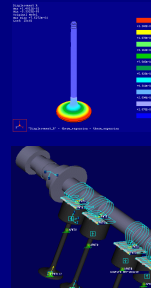
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Customization

Capturing Your Proprietary Process Knowledge

- **Captures user knowledge throughout process**

- **Enables process synchronization**

- **Facilitates best practices standardization**

Customized Codes

Interfacing with user specific programs

ä   Plugs in with custom software programs
- ä 2-D electrode/CFD Flow Field Modes
- ä Thermal Models
- ä PEM Stack Model (LANL)
- ä Fuel Processor/Prox Models

ä   Bi-directional communication/interfaces can be developed

ä   Allows for addressing Fuel Cell needs and concerns
- ä Anode/Cathode Pressure
- ä Anode/Cathode Stoichiometry
- ä Thermal Management
- ä Water Management
- ä Impact of Auxiliary Loads

Security Measures

Protect proprietary data

ä Oracle based central database

ä Access controlled by user

ä Output of shell/skin information only if required

Pro/FUEL-CELL

Features	Benefits
ä Customizable environment and content databases to automate the design and development process	ä Capture and optimize the design process and geometry
ä On-line tutorial accessible from a vendor independent, multi-platform Web browser	ä Distributes knowledge easily and effectively to design teams
ä Interface based on standard Web technology	ä Uniform work environment incorporating process, design & validation
ä Automated geometry generator though the use of process wizards	ä Interactive tools to promote rapid part retrieval and model development

Conclusions

ä   To learn more about this concept, visit the NREL/PTC Booth

ä   This is a state-of-the-art optimization tool that is Web linked

ä   We have the potential to make large impacts on Fuel
    Cell development at the component and vehicle system level
    (as we did with HEVs)

ä   We need your participation and help!
   ä   How can what you are doing fit into the overall system approach?
   ä   How can this tool help you?
   ä   How can you impact this program?
   ä   Suggest ways to interface.
   ä   Define and capture associative impacts of change on first order
       designs.

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